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Water Environment Federation
the water quality people

THE Water Research FOUNDATION

2019 INTELLIGENT WATER SYSTEMS CHALLENGE

LAUNCH EVENT

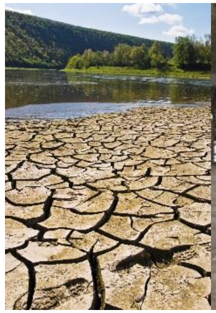
Thursday, January 31, 2019

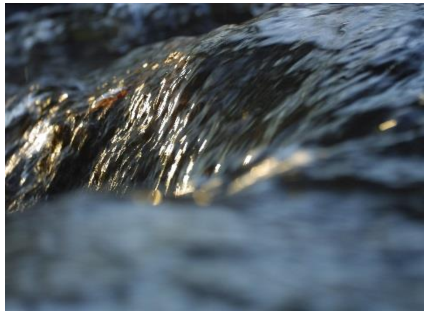
Agenda

- Background and Introduction
- LIFT IWS Challenge Overview
- Registration
- LIFT IWS 2018 Winners Presentation
- Q&A

Intelligent Water Systems Challenge

- Hosted through LIFT Intelligent Water Systems Workgroup
- Discussion on challenges to adopt smart water technologies





IWS Challenge Intent

Give students, professionals and technology aficionados the opportunity to showcase their talents and innovation, with a focus on leveraging data using the best available tools to help utilities better understand the dynamics of complex systems for making better decisions.

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Also supported by Cleveland Water Alliance, ISA, SWAN, The Water Council, and WaterTAP.

Suggested Problem Categories

- Collection Systems
- Wastewater Treatment Systems
- Drinking Water Treatment Systems
- Source Water/Watershed
- Distribution Networks
- Data Management
- Workforce of the Future

Utility Opportunities

- Design your own challenge problems
- Using real world data (if you like to use your own data, that will be ideal)
- Work with the team members to identify solutions based on smart technologies and IoT
- Receive innovative solutions to solve your problems
- Learn more about the state of the art in intelligent water technologies

Technology Provider Opportunities

- Understand utility challenges
- Get real-world data from utilities
- Work with the utilities to identify solutions through smart technologies and IoTs
- Individual technology applications addressing parts of a system/network
- Showcase your innovative solutions and apply to the real world!

Student and Aficionado Opportunities

- Apply your learning to real-world data
- Network
- Learn

What You'll Do – and We'll Evaluate

- Form a **Team**;
- Make a **Plan**:
  - Define the problem, understand the system, and lay out a plan;
- **Implement** your Solution:
  - Manage the data, do the analysis, communicate actionable results, and solve the problem;
- **Impress** the **Judges**!

Intelligent Water Systems Challenge **Judging Sheet**

TEAM NAME (team name)

JUDGE (judge name)

SCORE out of 140

	Raw (0-10)	x Weight =	Score
TEAM			
1 **Team** includes necessary skills and has appropriate utility input or *(partnered teams only)* representation.		x 1.0 =	out of 10
PLAN			
2 **Problem Statement** that shows understanding of how analytics can address utilities' challenges in utilities' terms *(partnered teams only)*.		x 2.0 =	out of 20
3 **Characterization of the Intelligent Water System** by describing the existing system or its salient parts.		x 1.0 =	out of 10
4 **Plan** that lays out a realistic timeline and approach for achieving the intended solution.		x 1.0 =	out of 10
IMPLEMENT			
5 **Data** streams are clearly identified and **QA/QC** appropriately discussed.		x 2.0 =	out of 20
6 **Analysis & Interpretation** deliver results that clearly support the intended solution.		x 2.0 =	out of 20
7 **Communication & Use** provide actionable results supporting decisions.		x 2.0 =	out of 20
8 **The Solution** meets utility expectations using appropriate tools.		x 2.0 =	out of 20
JUDGE'S IMPRESSIONS			
9 **Recognition** of alignment with IWSC goals, scalability and sustainability, lessons learned, and more.		x 1.0 =	out of 10

COMMENTS

LIFT IWS Challenge 2018 Winners

- Chris Maher – Clean Water Services Team
- Nina Kshetry – Ensaras Inc., MWRD Greater Chicago, and University of Illinois at Chicago Team
- Gregory Ewing – University of Michigan & Great Lakes Water Authority Team

Background

CleanWater Services

- Chris Maher – Operations Analyst II
  - Team Lead
- Perry Sunderland – Principal Engineer
- Tonya Zinzer – Energy Project Engineer
- Brandon Wick – Senior Automation Engineer
- Jeff VanNote – Information Systems Manager
- Ryan Sandhu – Field Operation Manager

Opportunity Statement

- Increase the influent wet well level for the facility Influent Pump Station (IPS) to:
  - Decrease energy consumption
  - Improve pump hydraulic conditions
  - Reduce O&M Costs
- Challenges with revised operation include:
  - Risk of sanitary sewer overflow (SSO)
  - Risk of blockage
  - Risk of odors

This slide should have been an animated cartoon schematic with the text narrated.

Opportunity Evaluation

This is the trimmed chart and it is still too much information, but shows that actual engineering was done to estimate the benfit of the IWS

Typical Flows	Typical Flows	# Operating Hours	Wet Well Levels (ft) & Estimated Power (kW)					
			103 ft. WW			115 ft. WW		
MGD	gpm	Hrs/Yr	Power (kW)	% Spd	dP	Power (kW)	% Spd	dP
17.5	12152	1974	277.94	80.20%	93.40	237.76	75.67%	81.4
31.2	21665.28	4294	515.604	79.00%	93.50	438.6	74.40%	81.5
48.4	33608.96	874	781.14	79%	92.60	664.65	74.41%	80.6
Totals		8130	3,445,373			2,933,591		
		Base Cost / Year	$ 206,722			$ 176,015		
Savings (kWh/yr)						511,783		
Cost Savings ($)						$ 30,707		
Cost Savings / Foot ($)						$ 2,559		

The Plan

We were trying to tell a story, so went for the story board here.

Creation of Team

- Focus on inclusion of staff across departments
  - Information Systems
  - Wastewater Treatment Department
  - Conveyance

Risk & Benefit Analysis

- Concerns – Addressed with Conveyance Model
- Benefits – Energy savings, Reduced O&M
- Challenges – Communication tool across departments

Creation of SOP

- Documentation on new strategy
- Identification of key process parameters
- Roll out to O&M staff

Implementation of IWS

- Beta-version of the information displayed on GIS
- Data package from Hach WIMS emailed to key personnel

Trial Period

- Trial 1: Aug. 21-Aug.28 6-hr Standard Mode
- Trial 2: Aug. 21-Present 30-hr Standard Mode

Evaluation

- Review data
- Document results
- Make recommendation

The Intelligent Water System

Again this could have been laid out graphically. A good visual depiction of the IWS that let's the audience quickly grasp the scope and range of devices is key.

Wastewater Treatment Department

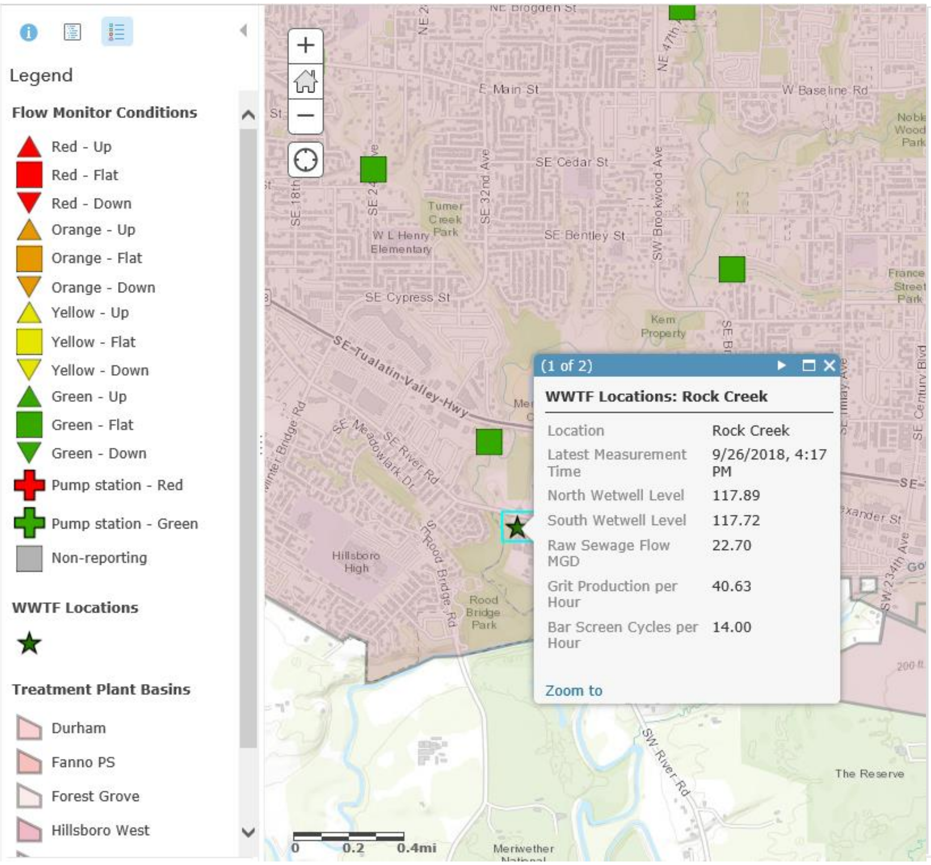
- IPS Level Indication
- IPS Flow
- IPS Pump Speed
- Grit Storage Load Cells
- Influent Screen Run Status

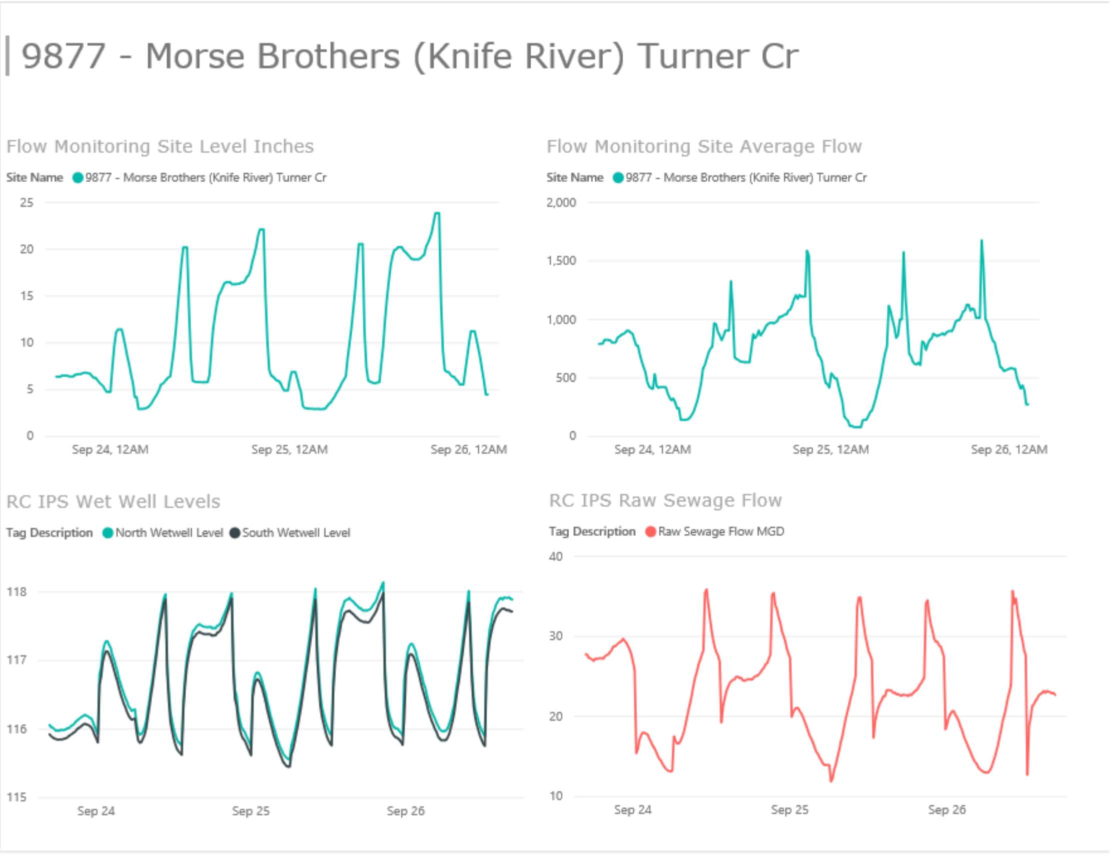
Field Operations

- Flo-Dar level, velocity and flow measurements
- H_2S OdaLog

Show how you communicate the data.

IWS – Arc GIS



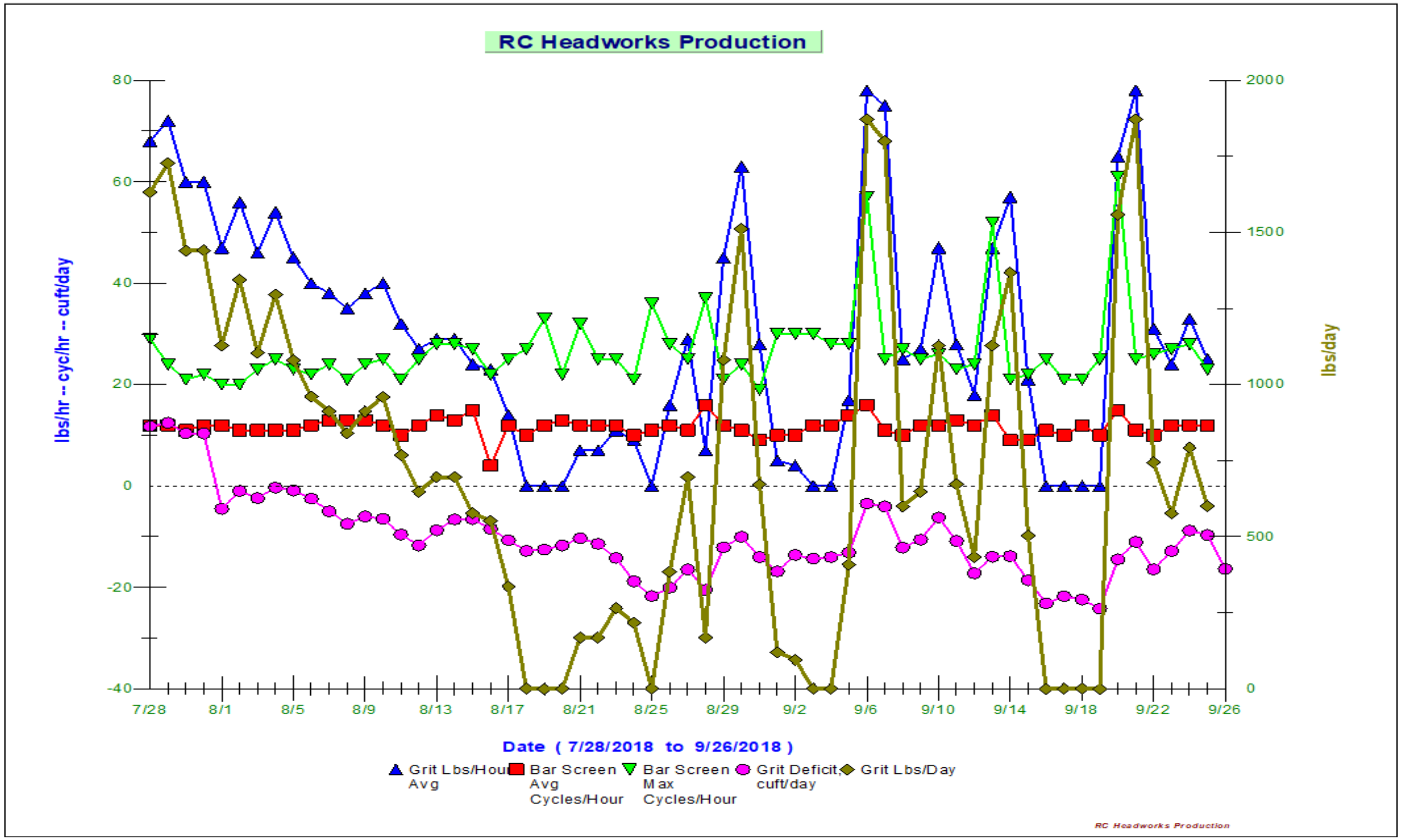


- Field Ops or WWTD, Operators work in real-time
- 15 min SCADA Data queried and integrated to ArcGIS
- Trend package developed in Power BI

Explain how the data is transformed into information.

IWS – Graph Package

- Leverage SCADA data to inform about conditions in conveyance
  - Bar Screen Cycles/hr
  - Grit Production lbs/hr
  - Grit Deficit deviation from 3 yr avg, in cu ft



How has the information increased knowledge and enabled consequential action.

Interpretation and Action

- Accumulation of screenings material in conveyance does not appear to be an issue
- Accumulation of grit in conveyance has the potential to be a huge issue
  - Weekly drawdown to remove grit
    - Initially 4 hours
    - Subsequently 36 hours
    - In trial for one week
- From two 900 hp pumps to one 400 hp pump

“Demonstrate the value of Intelligent Water Systems”

Value

- Quantified Benefits:
  - $700,000 savings 20-Year Net Present Value
    - Energy Savings
    - Reduction in pump clogging
    - Reduced maintenance over time
    - Reduced wear due to improved hydraulic conditions
- Unmeasured Benefits:
  - Organizational culture
    - Data sharing across departments
    - Secondary ownership of conveyance and treatment

I might have moved this slide up one, to be able to finish by making a strong statement about value.

Next Steps

- Discuss proposed operating procedures moving forward
  - Validate duration of high efficiency mode
  - Drawdown scheduling
- Expand the IWS
  - Rainfall gauges
  - Radar weather data
  - Pump station operational data
- Automate the wet well level operation based upon input data from the IWS

Read the Guidance

The Challenge seeks to foster the adoption of smart water technologies by showcasing the ability of intelligent water systems to effectively leverage data for better decisions.

Solution Goals:

- Demonstrate the value of intelligent water systems
- Leverage data using the best available tools to better understand and make decisions.

There is no constraint on organizational affiliations of the team members and full flexibility in team membership. We envision some teams with multiple (or even all) members from the same utility, perhaps taking advantage of the Challenge to build better inter-departmental ties.

My Advice

- It’s a short time frame, especially if it’s added on top of existing workflow
  - Pick something you’re currently working on
  - Installing and commissioning devices can be time consuming, look to leverage existing data
  - Set realistic expectations for results (get results!)
- Solution Submission
  - Excellent guidance provided
  - Volunteer Judges
  - Make something decent to read – it’s not a technical paper, it’s a story

My Take Home

Data → Information → Knowledge → Action

Developing an Intelligent Advanced Warning System for Odors
at MWRDGC's Thornton Composite Reservoir

INTELLIGENT WATER SYSTEM CHALLENGE 2018

Wastewater Management

Actionable Insight

Team

Data-Driven Decisions

Artificial Intelligence

A Utility-Industry-Academia Partnership

- Dr. Kuldip Kumar, Team Leader, MWRDGC
- Dr. Dominic Brose, MWRDGC
- Ms. Nina Kshetry, Ensaras, Inc.
- Prof. Lav Varshney, Ensaras, Inc. & Univ. Illinois
- Mr. John Mulrow, University of Illinois at Chicago
- Mr. Darshan Jain, University of Illinois at Chicago

Background

MWRDGC's Tunnels and Reservoir Plan - TARP

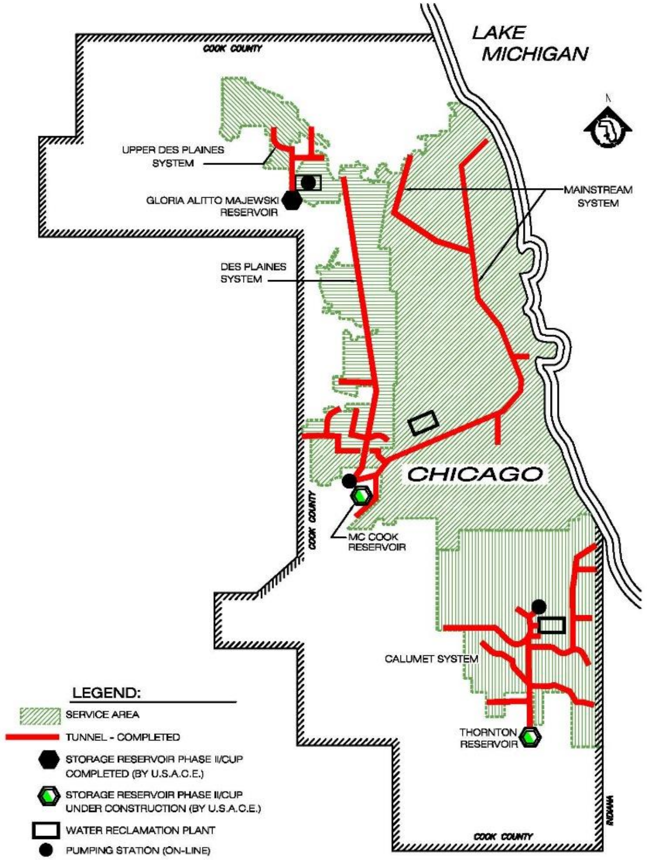
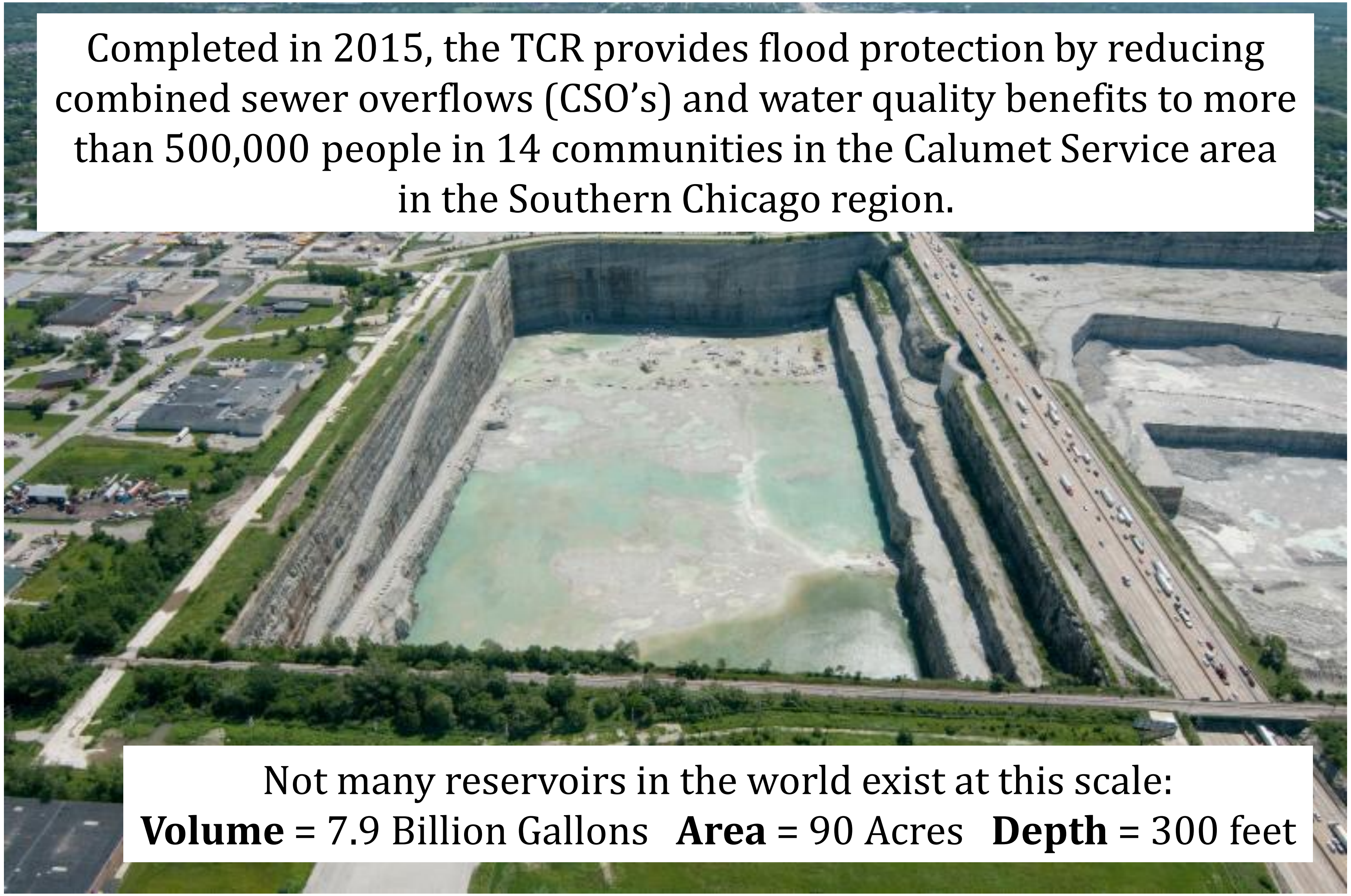


Figure 3: Tunnel and Reservoir Plan Project Status

Thornton Composite Reservoir (TCR)

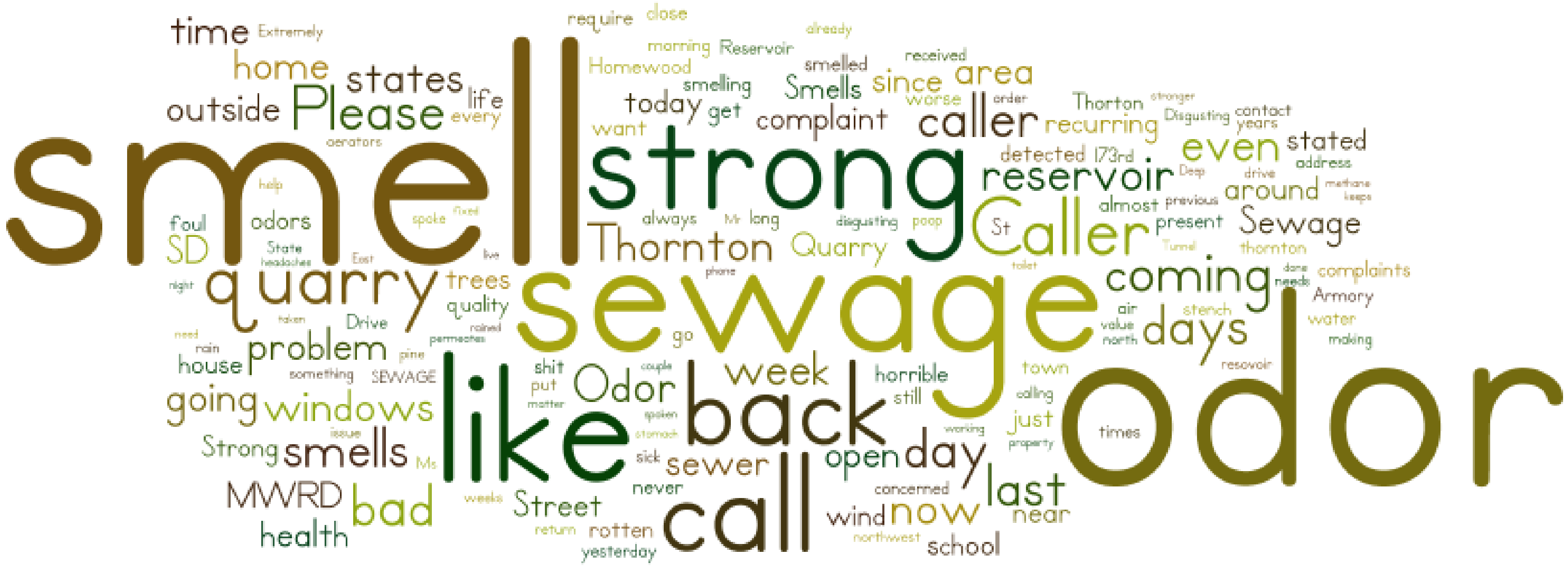
Completed in 2015, the TCR provides flood protection by reducing combined sewer overflows (CSO's) and water quality benefits to more than 500,000 people in 14 communities in the Calumet Service area in the Southern Chicago region.



Not many reservoirs in the world exist at this scale:
Volume = 7.9 Billion Gallons **Area** = 90 Acres **Depth** = 300 feet

Problem Statement

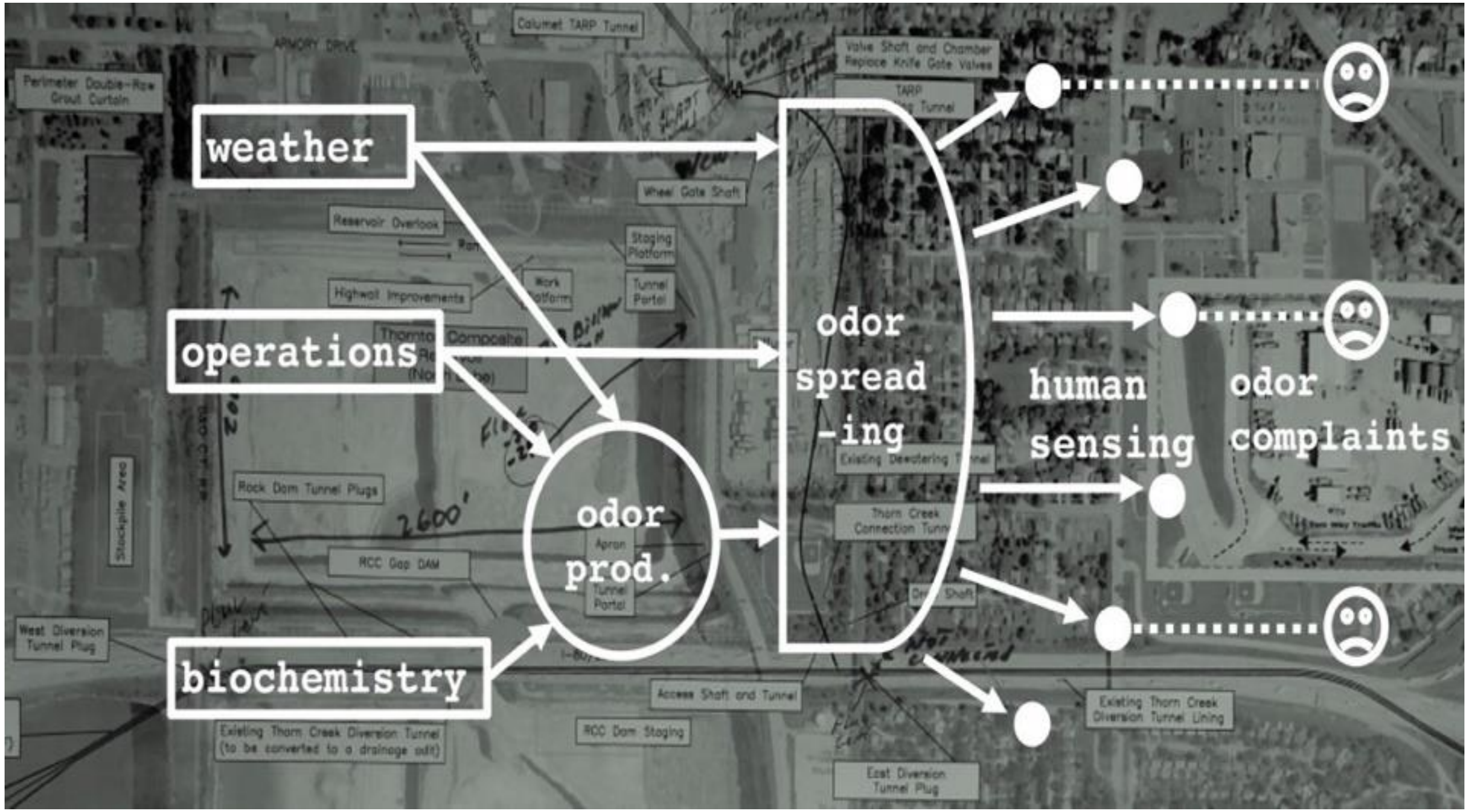
- Soon after TCR went online in 2015, MWRDGC started to receive odor complaints from surrounding neighborhoods.



- Given system complexity, including the many factors that impact odor generation, dispersion, and human smell perception / complaint behavior, and the sheer scale of the reservoir, it is difficult to predict odor complaints in advance or to determine the exact source of odor.

Project Goals

- Advanced odor warning system.
  - **Three-days** advanced warning
  - At least **60 percent accuracy**
  - Less than **25 percent false positives**
- Insight into the sources of and factors that influence odor events.
- Ongoing odor monitoring plan.
- Odor remediation strategies.



Algorithm Development

Data Types	Role in Algorithm
H_2S Sensors	Attribute
NOAA Weather	Attribute
TCR Operations	Attribute
Odor Complaints	Label

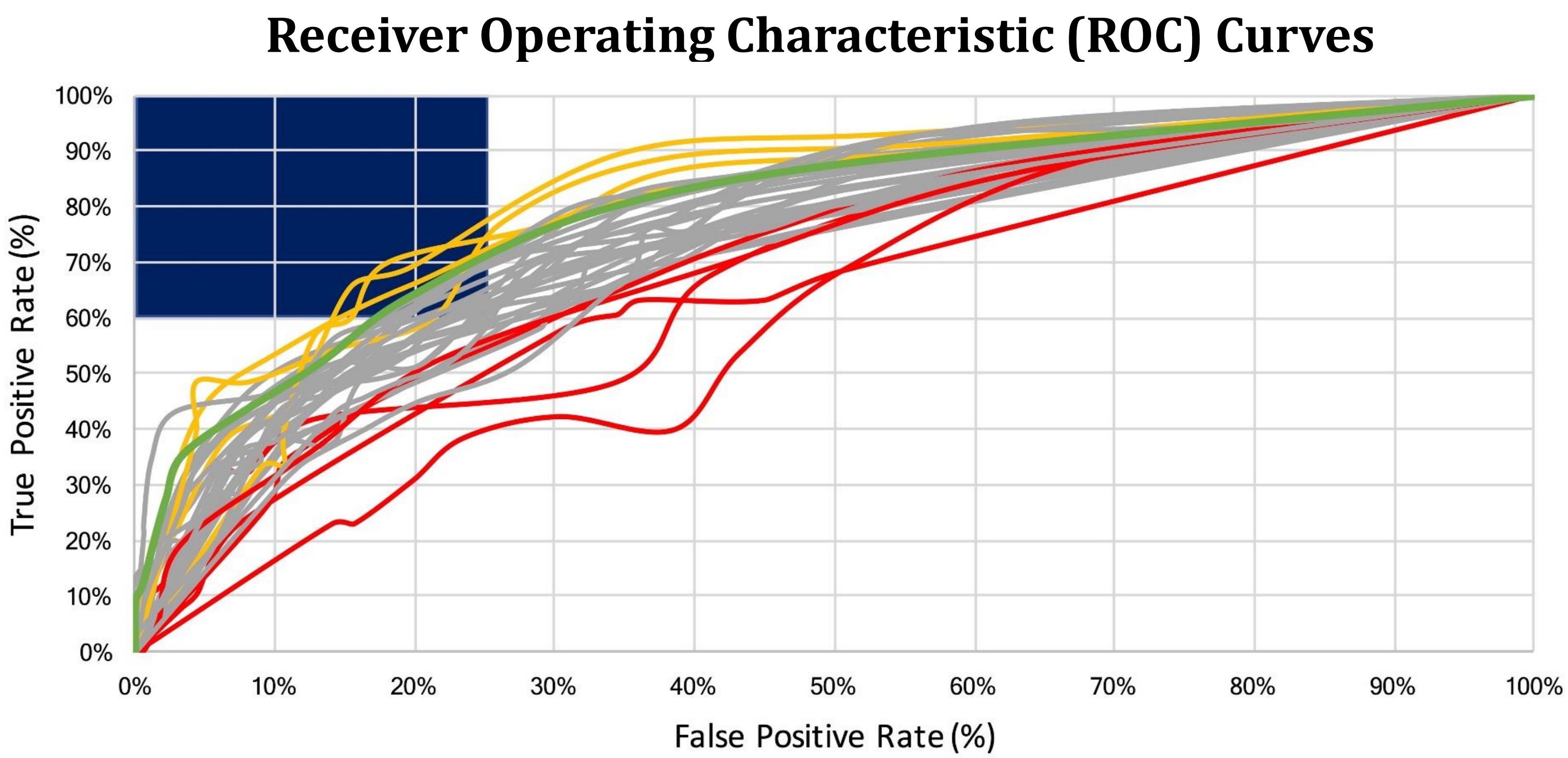
Training Data: 2016 to 2018

Date	Days Prior	Wet Well Drop Shaft Max H2S	NE Corner Max H2S	NW Corner Max H2S	SE Corner Max H2S	SW Corner Max H2S	N Construction Drop Shaft Max H2S	S Creek Drop Shaft Max H2S
9/22/16	*16*	0.10	0	0.01	0	NA	NA	0
9/23/16	*15*	0	0	0	0	NA	NA	0
9/24/16	*14*	0.01	0	0.01	0	NA	NA	0
9/25/16	*13*	0	0	0.01	0	NA	NA	0
9/26/16	*12*	0.18	0.01	0	0	NA	NA	0
9/27/16	*11*	2.00	0.01	0	0	NA	NA	0
9/28/16	*10*	0.62	0.01	0.01	0.02	NA	NA	0.01
9/29/16	*9*	0.71	0	0.15	0.02	NA	NA	0
9/30/16	*8*	0.17	0	0.04	0.01	NA	NA	0
10/1/16	*7*	1.75	0.08	0.24	0.34	NA	NA	0.09
10/2/16	*6*	0.04	NA	0.02	0.02	NA	NA	0.01
10/3/16	*5*	0.12	0.05	NA	0.03	NA	NA	0.03
10/4/16	*4*	0.31	0.06	NA	0	NA	NA	0
10/5/16	*3*	2.00	NA	NA	0.12	NA	NA	0.04
10/6/16	*2*	0.79	NA	NA	0.83	NA	NA	0.05
10/7/16	*1*	0.05	NA	NA	0.1	NA	NA	0.01

Date	Wet Well Drop Shaft H2S Concentration								
	3-day prior	4-day prior	5-day prior	6-day prior	7-day prior	AVG 1-week prior (3-9 days)	MAX 1-week prior (3-9 days)	AVG 2-week prior (3-16 days)	MAX 2-week prior (3-16 days)
10/8/16	2.00	0.31	0.12	0.04	1.75	0.73	2.00	0.57	2.00

Supervised Learning: We used labeled historical data to train a model to make predictions in the future.

Algorithm Evaluation and Results



Combining H_2S sensor (3 locations), NOAA weather, and TCR Operations Data resulted in good prediction performance.

Selected Algorithm:
Random Forest Classifier with Random Oversampling

Attributes: Drop shaft Odalog data + TCR operations + NOAA weather

Area Under Curve: 0.796

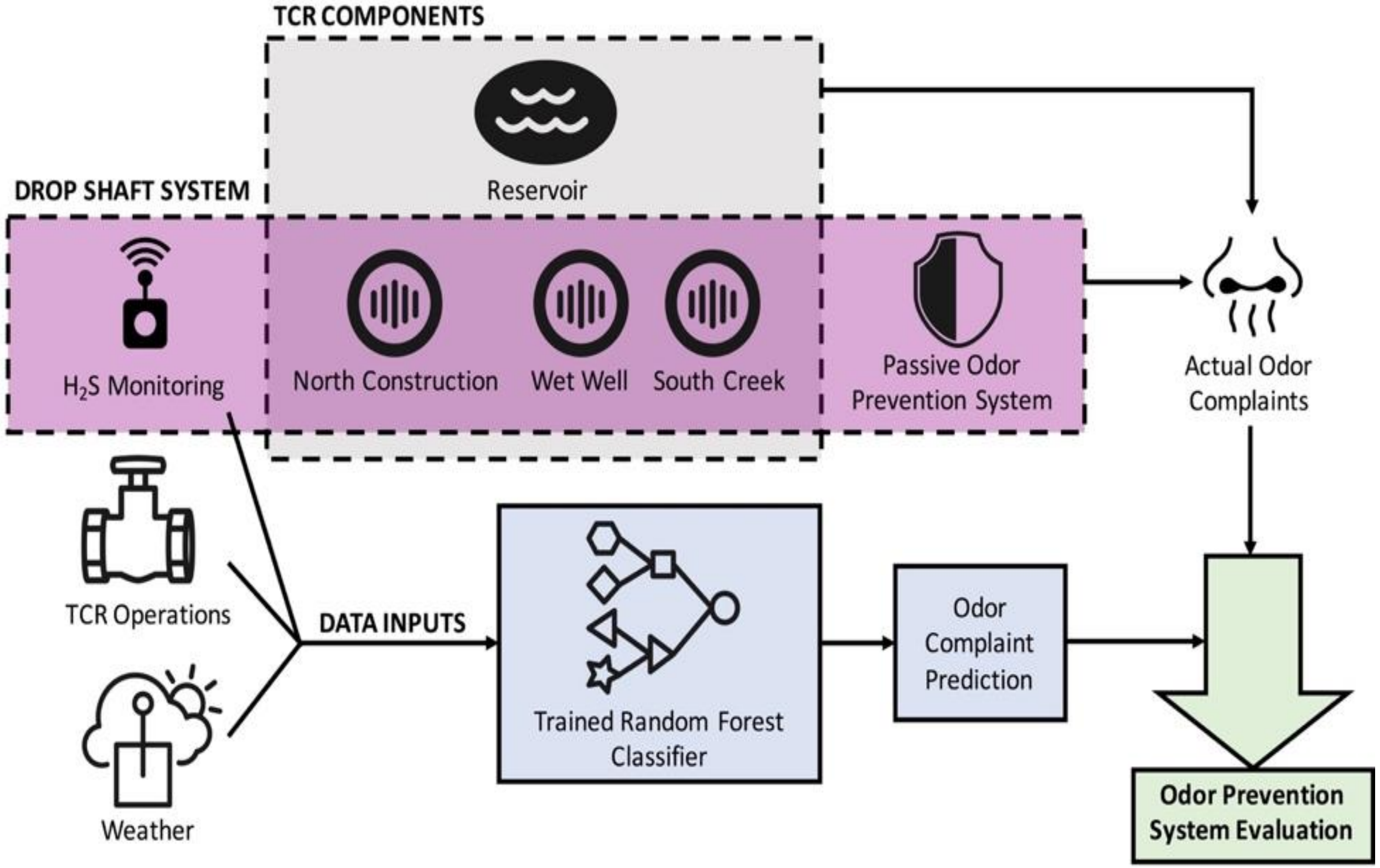
Max Accuracy:
> 70% True Positives
< 25% False Positives

Most Important Attributes:

- Wet Well Drop Shaft
- Relative Humidity
- Wind Speed
- Wind Direction
- Dry Bulb Temperature
- TCR Elevation

Communication and Use

- MWRDGC ruled that chemical treatment is too costly with unpredictable results due to challenges of scale and complex operation, instead will install an activated carbon filter at the wet well drop shaft.
- Results suggest drop shafts as a source of H_2S, with wet well drop shaft being a strong feature.
- Drop shaft H_2S monitoring is more manageable and cost-effective than monitoring at TCR corner locations.
- For TCR corners associated with odor, MWRDGC is researching planting of trees to alter dispersion patterns.



Algorithm will be used to evaluate odor mitigation strategies

Communication and Use

Data Collection Improvement Plan

- Manual downloading of Odalog sensor data is cumbersome.
- Piloting sensor technology with wireless telemetry.
- Continue to collect TCR operations data and NOAA weather data.

Deployment Beyond TCR

- Odor prediction approach and data management improvement plans directly generalize beyond TCR.
- MWRDGC itself plans to implement this and similar approaches at other reservoirs connected with the tunnel system.
- Machine learning approach can be implemented by other utilities with similar tunnels and reservoirs for CSO control.

Conclusions and Lessons Learned

We have developed the next stage of odor control measures at TCR, resulting in improved data sensor technology, better data handling, and deployment of a trained odor prediction algorithm to improve the lives of the surrounding community.

multifarious, incomplete, noisy data → **quality assurance / quality control** → **machine learning training** → **data-driven insight + expert knowledge** → **deployment**

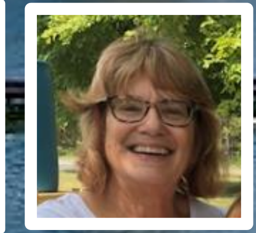
Concrete example of artificial intelligence and machine learning—based on sensor and operational data—solving an important water resource recovery industry problem.

Feedback for Future LIFT IWS Challenge Applicants

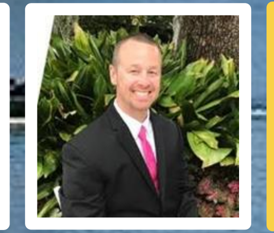
- Take the time to understand the problem and the desired solution at the beginning; use the utility experts!
- A substantial amount of time and effort can be involved in data pre-processing /clean up.
- Think about how the solution will be integrated and implemented at the beginning.
- Determine the economic and sustainability value of your solution, and make an impact statement for stakeholders.
- Identify a utility champion, who will move the project forward after the challenge ends.
- Determine if any ongoing projects may be a good fit for the challenge, you don't have to begin a new project.

Open-Storm Detroit Dynamics

Utility-University Team

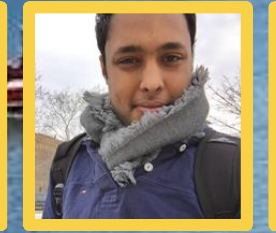


Wendy Barrott



Christopher Nastally

Gregory Ewing



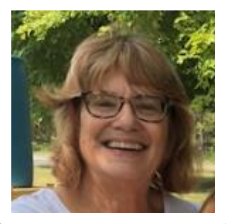
Abhiram Mullapudi

Sara Troutman

Branko Kerkez

Open-Storm Detroit Dynamics

Utility-University Team



Research & Innovation

CSO Control Program

Research Staff

Ph.D. Candidate

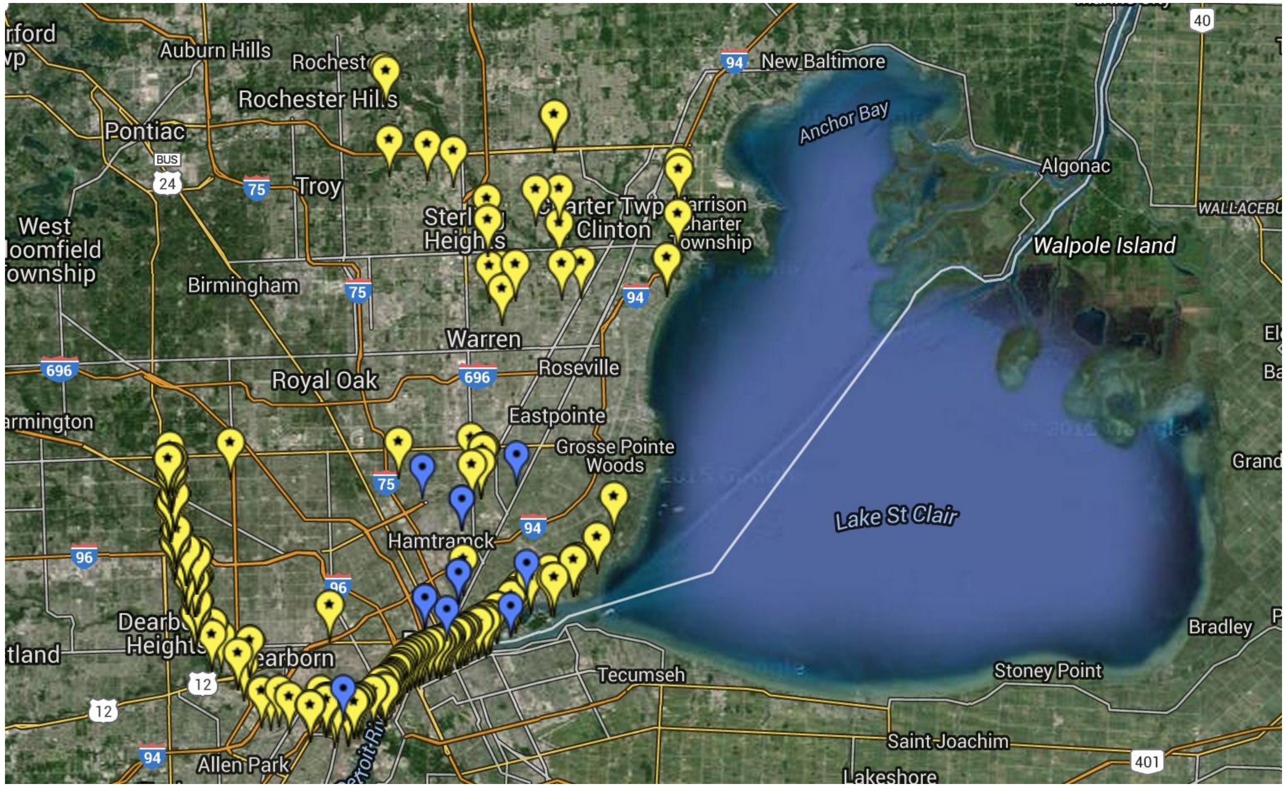
Professor

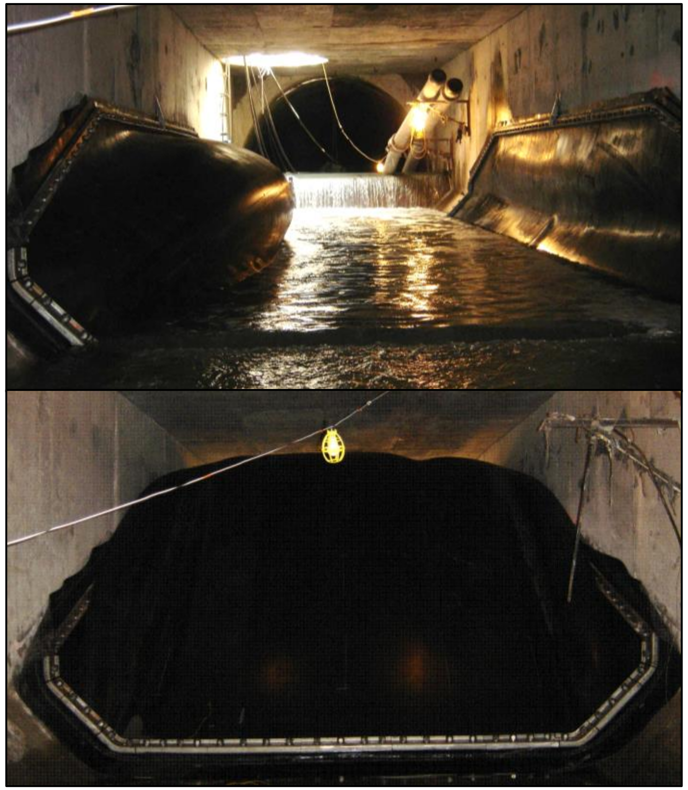
Ph.D. Candidate

2019 LIFT INTELLIGENT WATER SYSTEMS CHALLENGE

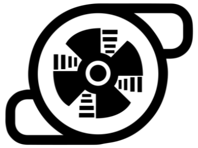
The Problem

The Opportunity



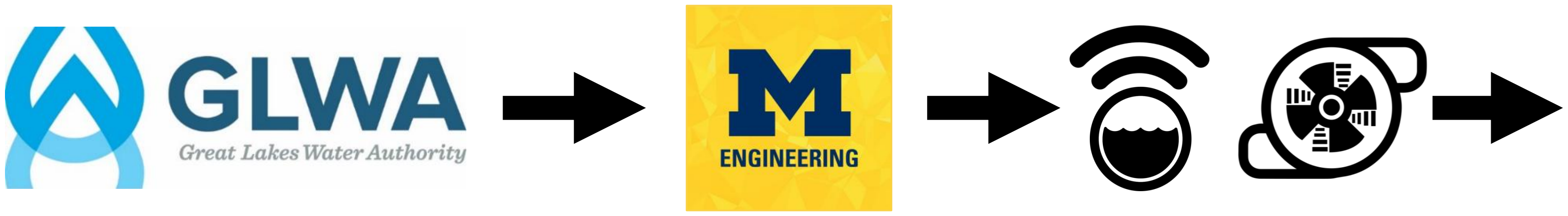



100+ Sensors


20+ Control Points

The Plan

Nov 2017 – Nov 2018



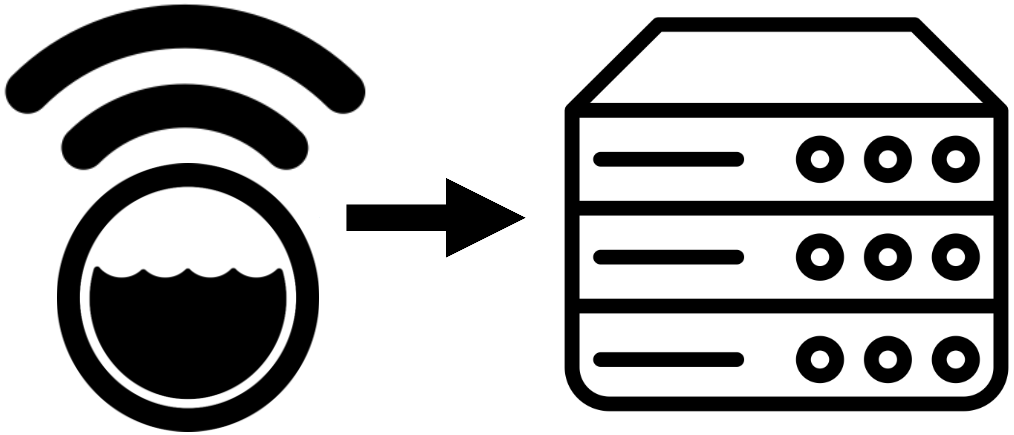
Outcomes & Considerations

1. No New Construction
2. Maximize Storage
3. Reduce CSOs
4. Equalize Flows

Existing SCADA Workflow

Sensors

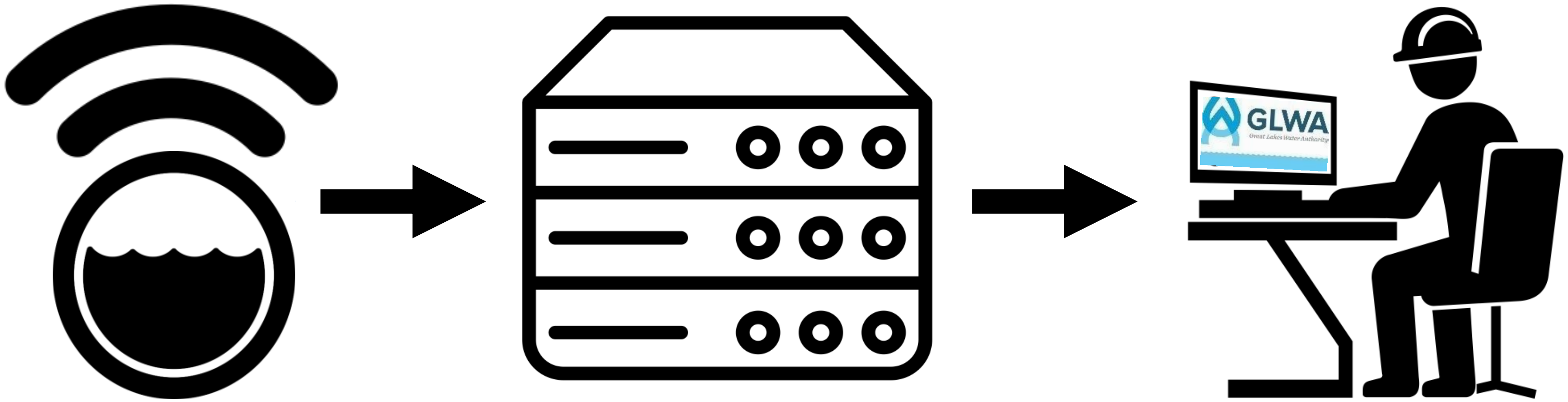
Existing SCADA Workflow



Sensors

Utility
Server

Existing SCADA Workflow

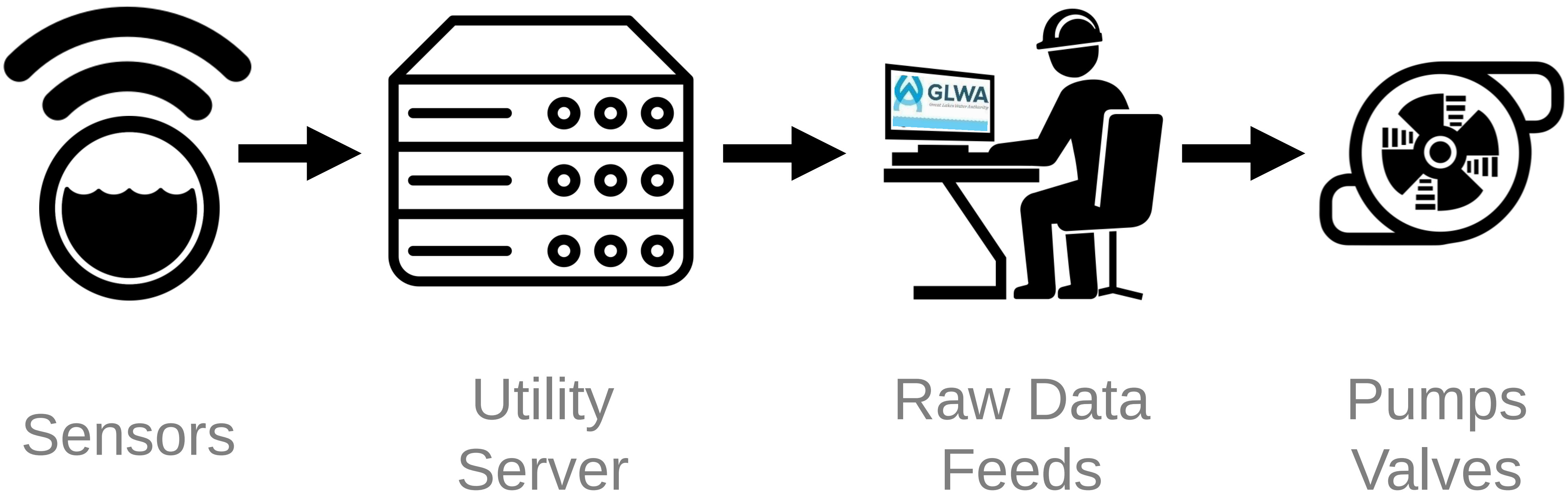


Sensors

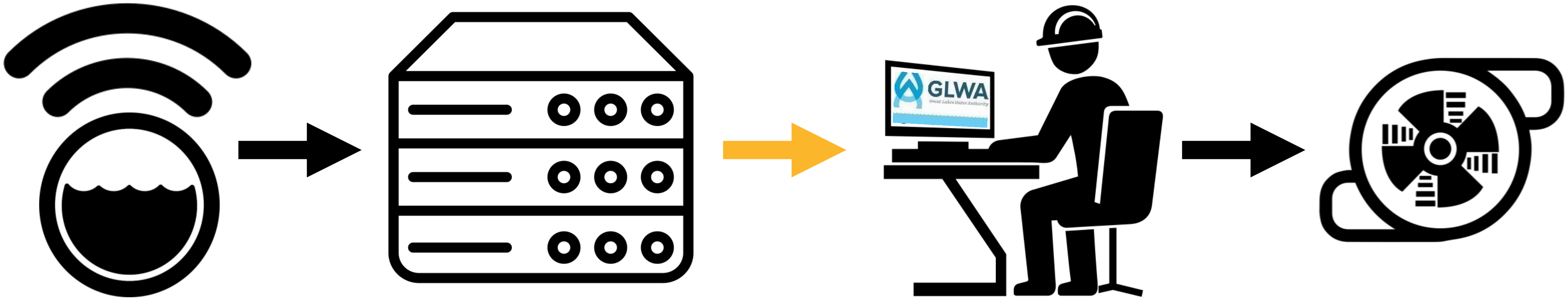
Utility Server

Raw Data Feeds

Existing SCADA Workflow



Existing SCADA Workflow



Sensors

Utility Server

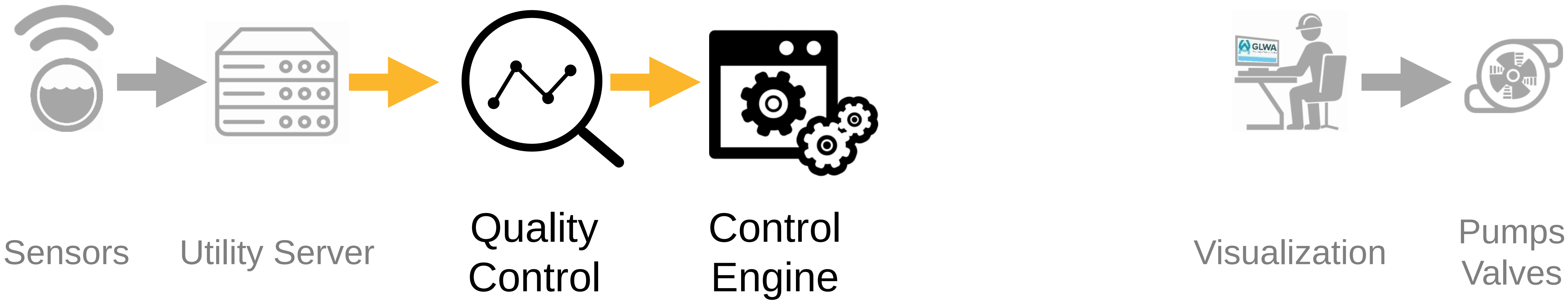
Raw Data Feeds

Pumps Valves

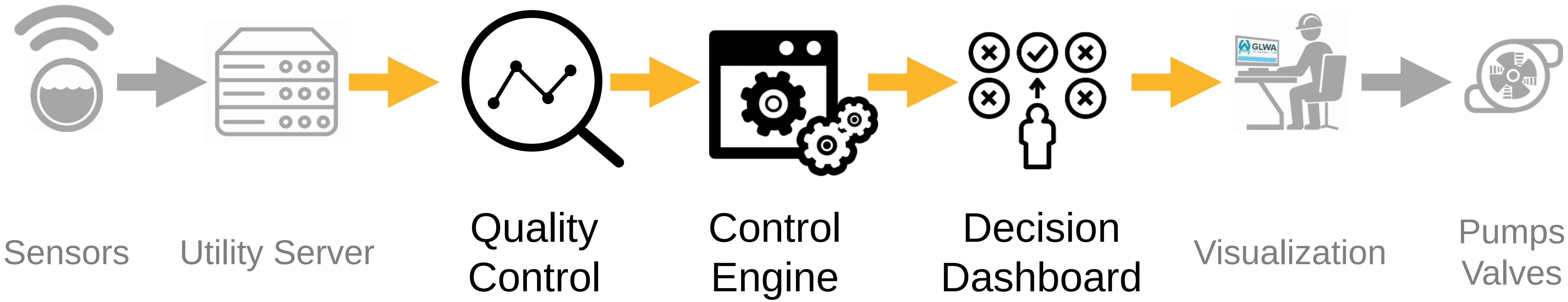
Description of Smart Water System

Description of Smart Water System

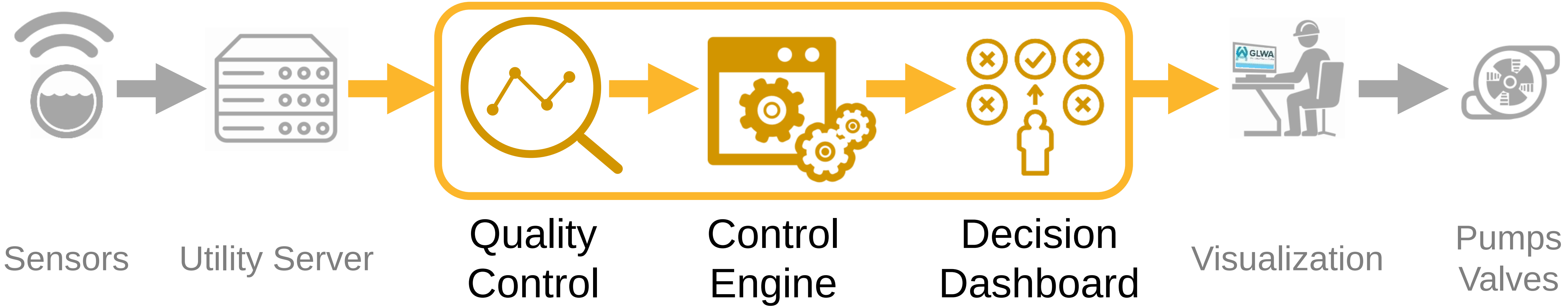
Description of Smart Water System



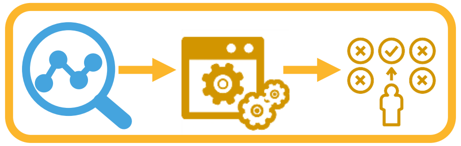
Description of Smart Water System



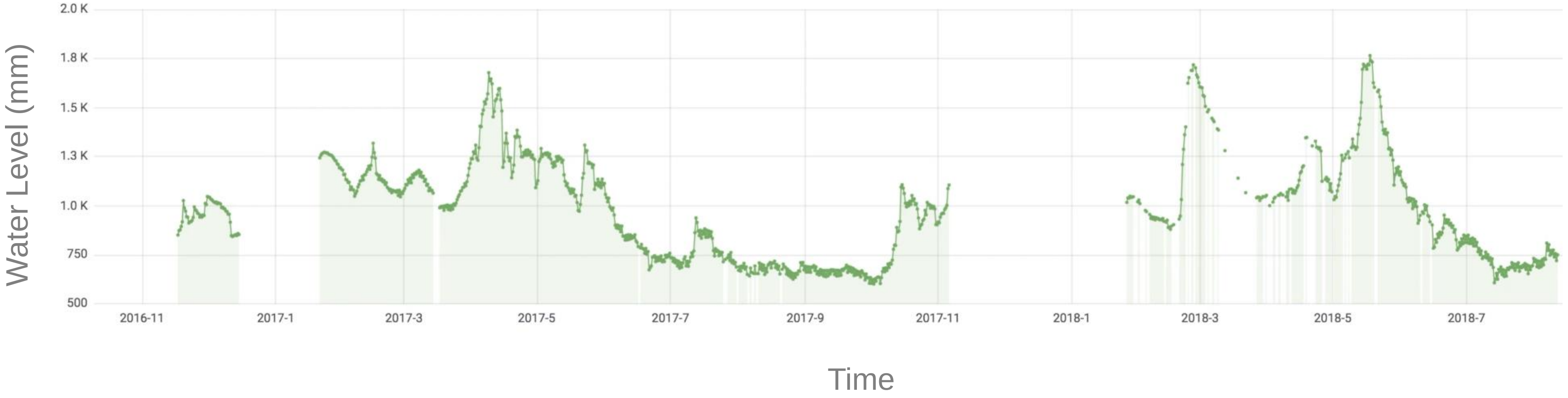
Description of Smart Water System



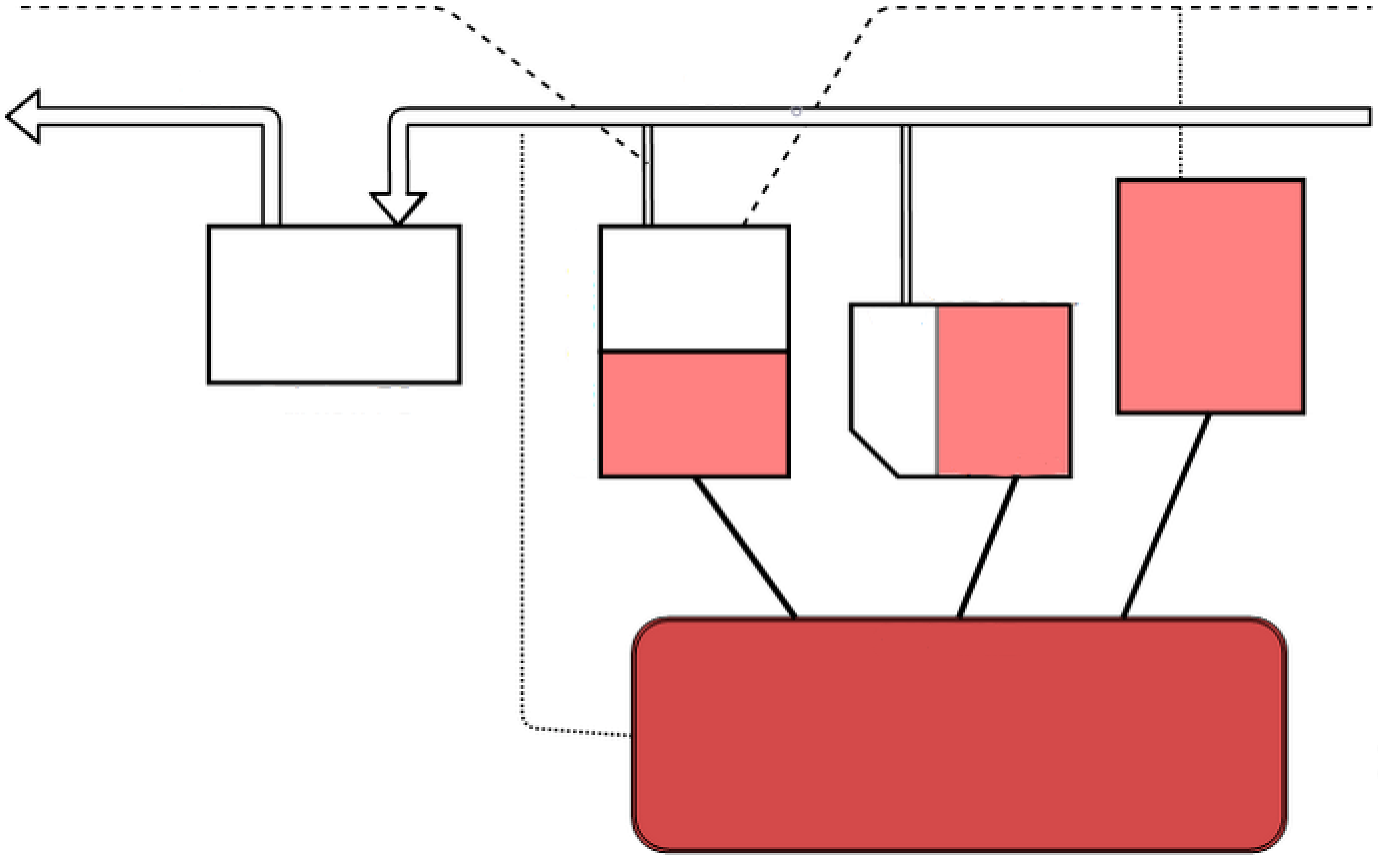
RAW WATER LEVEL DATA



Real-time QA/QC



Under The Hood



Upstream Downstream

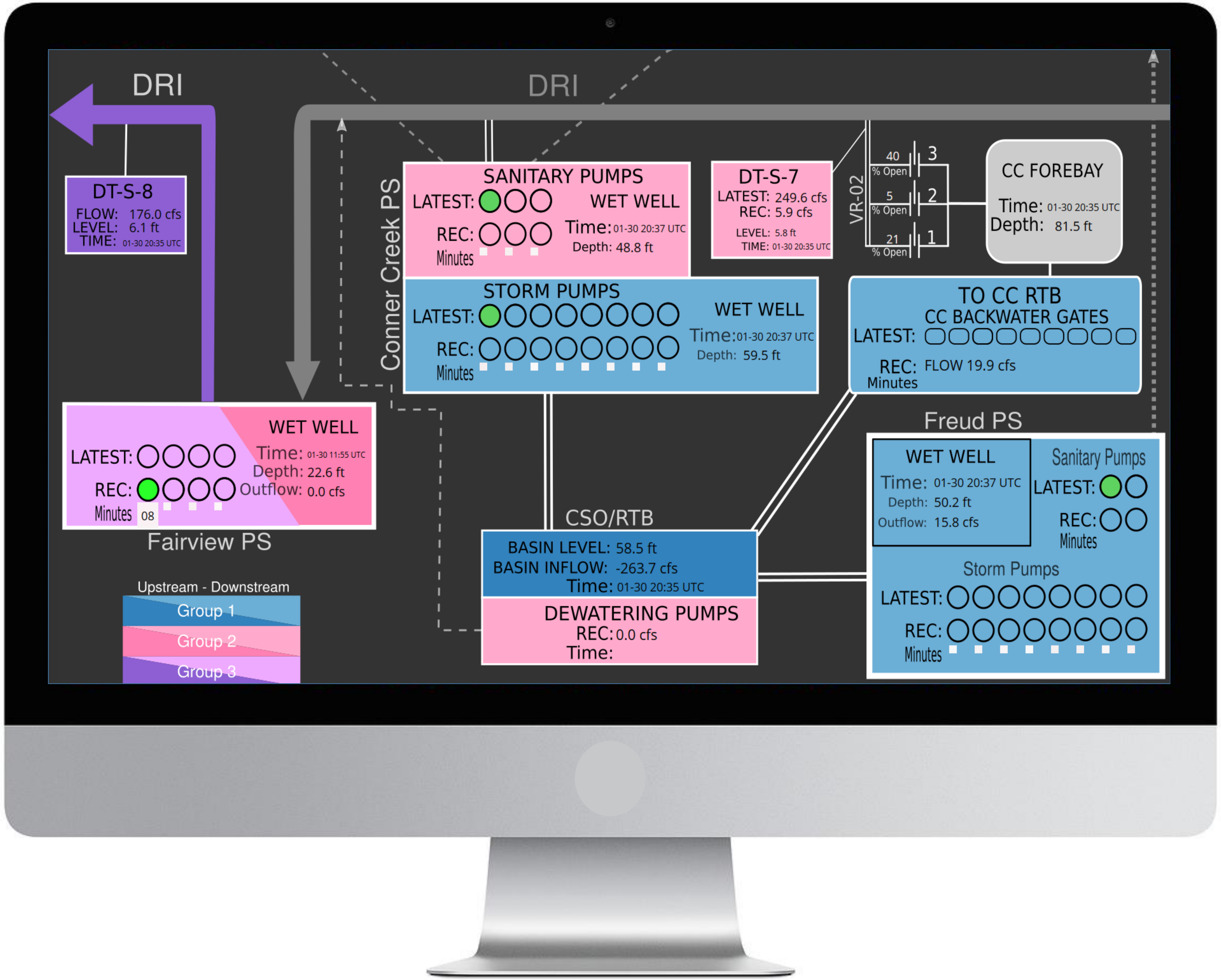
$$W_i = \beta_i \cdot V_{up,i}$$

$$D = (V_{down} - setpoint) \cdot \varepsilon$$

$$p = \frac{1}{n+1}\left[\sum_i W_i + D\right]$$

$$Q_{goal,i} = Q_{available} \cdot (W_i - p)$$

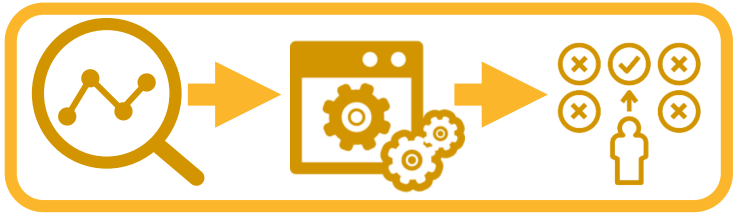
$$Q_{goal,i} \rightarrow Recommendation$$



DRI
DRI
DT-S-8
FLOW: 176.0 cfs
LEVEL: 6.1 ft
TIME: 01-30 20:35 UTC
Conner Creek PS
SANITARY PUMPS
LATEST:
WET WELL
REC:
Minutes
Time: 01-30 20:37 UTC
Depth: 48.8 ft
DT-S-7
LATEST: 249.6 cfs
REC: 5.9 cfs
LEVEL: 5.8 ft
TIME: 01-30 20:35 UTC
VR-02
40 % Open 3
5 % Open 2
21 % Open 1
CC FOREBAY
Time: 01-30 20:35 UTC
Depth: 81.5 ft
STORM PUMPS
LATEST:
WET WELL
REC:
Minutes
Time: 01-30 20:37 UTC
Depth: 59.5 ft
TO CC RTB
CC BACKWATER GATES
LATEST:
REC: FLOW 19.9 cfs
Minutes
WET WELL
LATEST:
Time: 01-30 11:55 UTC
Depth: 22.6 ft
REC:
Outflow: 0.0 cfs
Minutes 08
Fairview PS
CSO/RTB
BASIN LEVEL: 58.5 ft
BASIN INFLOW: -263.7 cfs
Time: 01-30 20:35 UTC
DEWATERING PUMPS
REC: 0.0 cfs
Time:
Freud PS
WET WELL
Time: 01-30 20:37 UTC
Depth: 50.2 ft
Outflow: 15.8 cfs
Sanitary Pumps
LATEST:
REC:
Minutes
Storm Pumps
LATEST:
REC:
Minutes
Upstream - Downstream
Group 1
Group 2
Group 3

Value Added

Smart System



100 MG CSO Reduction
Per Event

VS

Capital Improvements

100 MG Storage
for $500 Million

Competition Advice

- Stay Organized!
- Leverage Utility Resources
- Persistence
- Submit your final work!

open-storm.org/LIFT

Intelligent Water Challenge Deadlines

- **January 31** LIFT IWS Challenge Webinar
- **February 11** Challenge Launch
- **March 8** UMC 2019 In-Person Meeting
- **March 25** Team Registration Deadline
- **April 22** Challenge Plan Deadline
- **April 22 – April 26** Optional check-in with Steering Committee
- **May 20 – May 24** Required check-in with Steering Committee
- **August 2** Challenge Solution Deadline
- **September 23** Finalist presentations and awards at WEFTEC'19

Q&A